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(54) System for utility demand monitoring and control

(57) A system for electric power demand monitoring and control includes one or more data distribution networks interconnecting intelligent utility units located at customer homes with a host computer located in the utility company offices. Each intelligent utility unit is associated with a customer home for connecting and disconnecting a power service meter, monitoring customer demand, and controlling power to selected units. A network within the home interconnects each intelligent utility unit with power consuming units for providing data on power usage and power control. A data distribution network interconnects the plurality of intelligent utility units to the host computer as a head end unit, the data distribution network providing downstream communication channels from the host computer to the plurality of intelligent utility units and upstream communication channels from the plurality of intelligent utility units to the host computer. The communication channels are organized as frequency division multiplex channels in a frequency spectrum. A plurality of distribution networks can be provided for a larger utility environment with each distribution network associated with a power substation and customers served by the power substation.

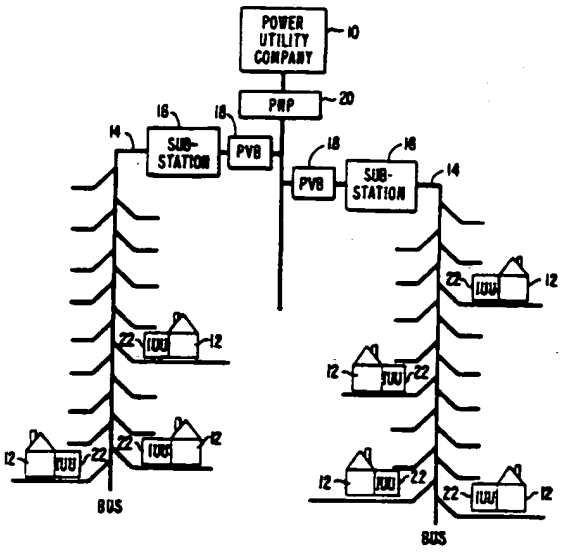

FIG. 1.

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In a mid-split system, the frequencies from 5 to 108 MHz (17 channels) are used to carry signal in the inbound direction, and the frequencies from 162 MHz to 1 GHz (50+ channels) are used to carry signals in the outbound direction. See Table 2 for a representative mid-split cable spectrum.

In a high-split system, the frequencies from 5 to 175 MHz (30 channels) are used to carry signals in the inbound direction, and the frequencies from 220 MHz to 1 GHz (35+ channels) are used to carry signals in the outbound direction. See Table 3 for a representative high-split cable spectrum.

A multi-tiered addressing scheme is employed in the network. Each IUU contains the following address structure:

Physical unit address--six-byte address unique to every unit. The address is written in HEX and coded into each IUU.

Group address--allows addressing of assigned group less than all users.

Broadcast address--allows addressing of all system users.

This addressing structure allows the network manager to directly communicate with each individual IUU, a group of IUUs, and all IUUs.

The gateway between the distribution network and the digital backbone interfaced to the host computer is located in the utility company substations. A power view bridge (PVB) provides the routing function between the distribution network and the backbone network. The bridge processor keeps track of IUU addresses and the network processor address and performs the routing function for all packets between the networks. The bridge also performs a filtering function in passing data only to valid known addresses.

Fig. 6 is a functional block diagram of the digital backbone network which interfaces the host computer with the plurality of distribution networks. The backbone network includes a Frame Relay T1 interface for providing the interface between the gateway and the backbone network. A PowerView Network Processor (PNP) which provides an interface between T1 data streams and the utility host computer which provides the management of the overall network. The backbone network can be organized as a star, ring or bus. The actual topology is not important since circuits will be dedicated from the utility substations to the host computer. The digital circuits terminate at a PNP near the utility company's host computer. The backbone network can operate from T-1 rates upwards and exceeding T-3 rates, depending upon network and utility size. The T1 network distribution media is twisted wire, optical fiber, coaxial cable, or microwave. The T3 networks are either fiber or microwave. Minimum network speed is T-1. Network addressing is a function of the circuits dedicated to the distribution network and a lower level addressing between the IUUs and the utility company's host computer.

The application package within the host computer includes the ability to collect information about time of day power consumption, the ability to remotely configure the home network through the IUU, the ability to change the price tier in real time either up or down as a function of power generation and consumption, and the ability to collect and process the customer's utility bill which breaks down power consumption by device, time of day, override conditions, and the like in order to provide an itemized billing statement to the customer.

There has been described a system for utility demand monitoring and control and including a distribution network which facilitates demand side management of utility consumption. While the system has been described with reference to an illustrative electric power utility embodiment, the description is illustrative of the invention and is not to be construed as limiting the invention. The system can be used with other utilities such as gas and water as well as with telephone and cable television networks. Other functions are readily incorporated such as security systems. Thus, various modifications and applications will occur to those skilled in the art without departing from the true spirit and scope of the invention as defined by the appended claims.

TABLE 1

SUB-SPLIT BROADBAND

GUARD BAND
30-54 MHz

Inbound Chnl	Inbound Band, MHz
T10	23.75-29.75
T9	17.75-23.75
T8	11.75-17.75
T7	5.75-11.75

PowerView Channels

Outbound Chnl	Outbound Band, MHz	
ZZ	450-456	
YY	444-450	
XX	438-444	
WW	432-438	
VV	426-432	
UU	420-426	
TT	414-420	
SS	408-414	
RR	402-408	
QQ	396-402	
PP	390-396	
OO	384-390	
NN	378-384	
MM	372-378	
LL	366-372	
KK	360-366	
JJ	354-360	
II	348-354	
HH	342-348	
GG	336-342 w/T10	Powerview Channels
FF	330-336 w/T9	
EE	324-330 w/T8	
DD	318-324 w/T10	
CC	312-318 w/T9	
BB	306-312 w/T8	
AA	300-306 w/T10	
W	294-300 w/T9	
V	288-294	
U	282-288	
T	276-282	
S	270-276	
R	264-270	
Q	258-264	
P	252-258	
O	246-252	
N	240-246	
M	234-240	
L	228-234	
K	222-228	
J	216-222	
13	210-216	
12	204-210	
2	54-60	

TABLE 2

BROADBAND

	Inbound Chnl	Inbound Band, MHz		Outbound Chnl	Outbound Band, MHz	
				ZZ	450-456	
				YY	444-450	
				XX	438-444	
				WW	432-438	
				VV	426-432	
				UU	420-426	
				TT	414-420	
				SS	408-414	
				RR	402-408	
				QQ	396-402	
				PP	390-396	
				OO	384-390	
				NN	378-384	
GUARD BAND 114-150 MHz				MM	372-378	
				LL	366-372	
				KK	360-366	
				JJ	354-360	
				II	348-354	
				HH	342-348	
				GG	336-342	
				FF	330-336	
				EE	324-330	
				DD	318-324	
				CC	312-318	
				BB	306-312	
	A2'	108-114		AA	300-306	
	FM3'	102-108		W	294-300	
PowerView Channels	FM2'	96-102		V	288-294	PowerView Channels
	FM1'	90-96		U	282-288	
	6'	84-90		T	276-282	
	5'	79-84		S	270-276	
	4A'	72-78		R	264-270	
	4'	66-72		Q	258-264	
	3'	60-66		P	252-258	
	2'	54-60		O	246-252	
	T14	47.75-53.75		N	240-246	
	T13	41.75-47.75		M	234-240	
	T12	35.75-41.75		L	228-234	
	T11	29.75-35.75		K	222-228	
	T10	23.75-29.75		J	216-222	
	T9	17.75-23.75		13	210-216	
	T8	11.75-17.75		12	204-210	
	T7	5.75-11.75		11	198-204	
				10	192-198	
				9	186-192	
				8	180-186	
				7	174-180	
				I	168-174	
				H	162-168	
				G	156-162	
				F	150-156	

TABLE 3

SPLIT BROADBAND

	Inbound Chnl	Inbound Band, MHz		Outbound Chnl	Outbound Band, MHz	
				ZZ	450-456	
				YY	444-450	
				XX	438-444	
				WW	432-438	
				VV	426-432	
	GUARD BAND			UU	420-426	
	186-222 MHz			TT	414-420	
				SS	408-414	
				RR	402-408	
				QQ	396-402	
				PP	390-396	
				OO	384-390	
				NN	378-384	
	8'	180-18·		MM	372-378	
	7'	174-18		LL	366-372	
	I'	168-17·		KK	360-366	
	H'	162-168		JJ	354-360	
	G'	156-162		II	348-354	
	F'	150-156		HH	342-348	
	E'	144-150		GG	336-342	
	D'	138-144		FF	330-336	
	C'	132-138		EE	324-330	
	B'	126-132		DD	318-324	
	A'	120-126		CC	312-318	
	A1'	114-120		BB	306-312	
PowerView	A2'	108-114		AA	300-306	PowerView
Channels	FM3'	102-108		W	294-300	Channels
	FM2'	96-102		V	288-294	
	FM1'	90-96		U	282-288	
	6'	84-90		T	276-282	
	5'	78-84		S	270-276	
	4A'	72-78		R	264-270	
	4'	66-72		O	258-264	
	3'	60-66		P	252-258	
	2'	54-60		O	246-252	
	T14	47.75-53.75		N	240-246	
	T13	41.75-47.75		M	234-240	
	T12	35.75-41.75		L	228-234	
	T11	29.75-35.75		K	222-228	
	T10	23.75-29.75				
	T9	17.75-23.75				
	T8	11.75-17.75				
	T7	5.75-11.75				

Claims

1. A system for utility demand monitoring and control comprising:

   a host computer having access to power utility customers for receiving customer data and providing management reports on customer demand and billing statements to customers,
   a plurality of intelligent utility units, each unit associated with a customer's home for connecting and disconnecting a service meter and monitoring customer utility demand,
   a home network interconnecting each intelligent utility unit with utility units within a home for providing data on utility usage, and
   a distribution network interconnecting said plurality of intelligent utility units.

2. The system as defined by claim 1 comprising communication channels which are organised as frequency and time division multiplexed channels in a frequency spectrum.

3. The system as defined by claim 1 or 2 comprising communication channels which include voice and data channels, and video channels.

4. The system as defined by claim 1, 2, or 3, wherein said distribution network comprises a fibre distribution network, or a coaxial distribution network, or a wireless network, or a combination of a fibre distribution network, a coaxial distribution network, and a wireless network.

5. The system as defined by any preceding claim wherein said host computer includes a digital backbone network for interfacing with said distribution network, said backbone interface including a Frame Relay with said distribution network and a Frame Relay router to interface the digital backbone data stream and said host computer.

6. The system as defined by any one of claims 1 to 4 wherein said host computer includes a digital backbone network for interfacing with said distribution network, said backbone interface including an ATM interface with said distribution network and an ATM interface router to interface the digital backbone data stream and said host computer.

7. The system as defined by claim 5 or 6 including a plurality of distribution networks each running from a power substation to a plurality of customer homes, said backbone network including a multiplexer for interfacing with said plurality of distribution networks.

8. The system as defined by any preceding claim, wherein said distribution network comprises a Frequency Division Multiplexed Cable TV system, containing a data stream in a television channel space, that contains a Time Division Multiplexed Voice Time Slot system, upon which a Carrier Sense Multiple Access with Collision Detection packet switched network is placed using at least one Voice Time Slot for packet data transmission.

9. A distribution network for communicating between a host computer and a plurality of customer homes in an electric power utility demand monitoring and control system, said distribution network comprising

   a plurality of intelligent units, each associated with a customer home for connecting and disconnecting a power service meter and monitoring customer power demand,
   a data transmission line interconnecting said plurality of intelligent utility units, said data transmission line providing downstream communication channels from said host computer to said plurality of intelligent utility units and upstream communication channels from said plurality of intelligent utility units to said host computer.

10. The distribution system as defined by claim 9 wherein said communication channels are organised as frequency and time division multiplexed channels in a frequency spectrum.

11. The distribution network as defined by claim 9 or 10 wherein said transmission line comprises a coaxial cable, or a fibre cable, or a wireless cable, or a twisted pair.

12. The distribution network as defined by claim 9, 10 or 11, wherein said distribution network comprises a Frequency Division Multiplexed Cable TV system, containing a data stream in a television channel space, that contains a Time Division Multiplexed Voice Time Slot system, upon which a Carrier Sense Multiple Access with Collision Detection packet switched network is placed using at least one Voice Time Slot for packet data transmission.

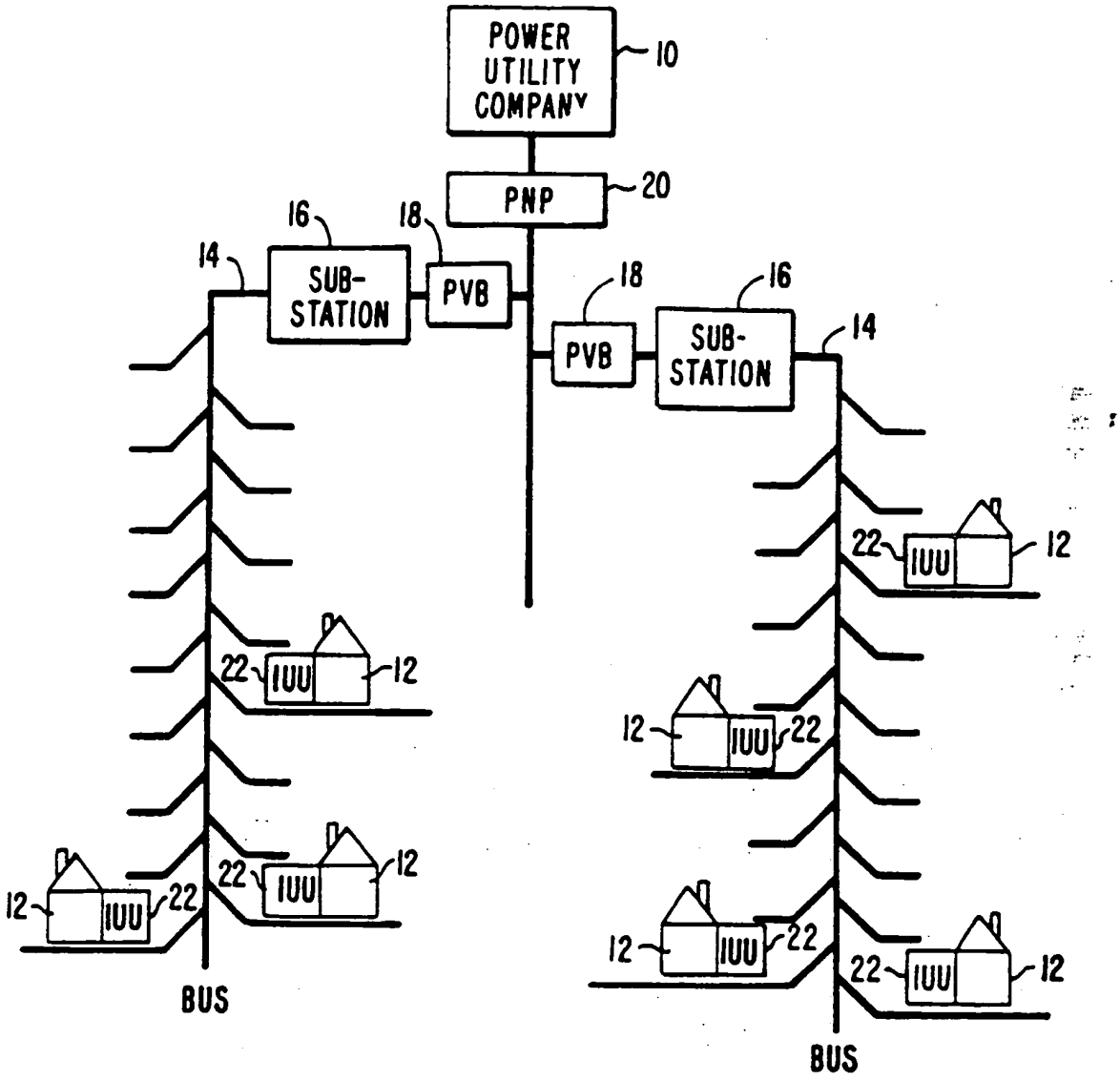
POWER UTILITY COMPANY
10
PNP
20
16
18
14
SUB-STATION
PVB
18
16
PVB
SUB-STATION
14
22
IUU
12
BUS
BUS

FIG. 1.

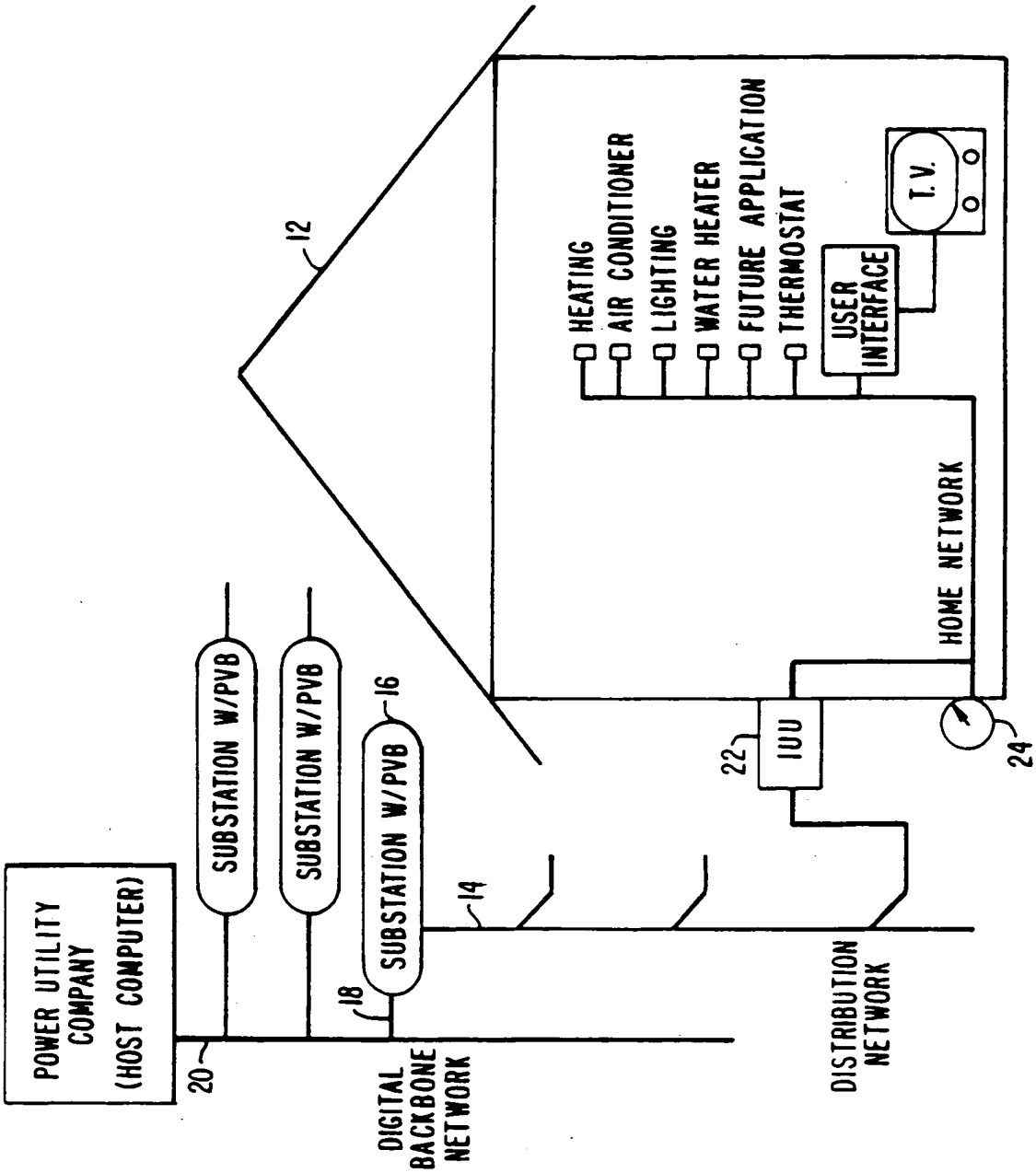
POWER UTILITY COMPANY (HOST COMPUTER)
20
SUBSTATION W/PVB
SUBSTATION W/PVB
SUBSTATION W/PVB
18
16
DIGITAL BACKBONE NETWORK
14
DISTRIBUTION NETWORK
22
IUU
24
12
HOME NETWORK
HEATING
AIR CONDITIONER
LIGHTING
WATER HEATER
FUTURE APPLICATION
THERMOSTAT
USER INTERFACE
T.V.

FIG. 2.

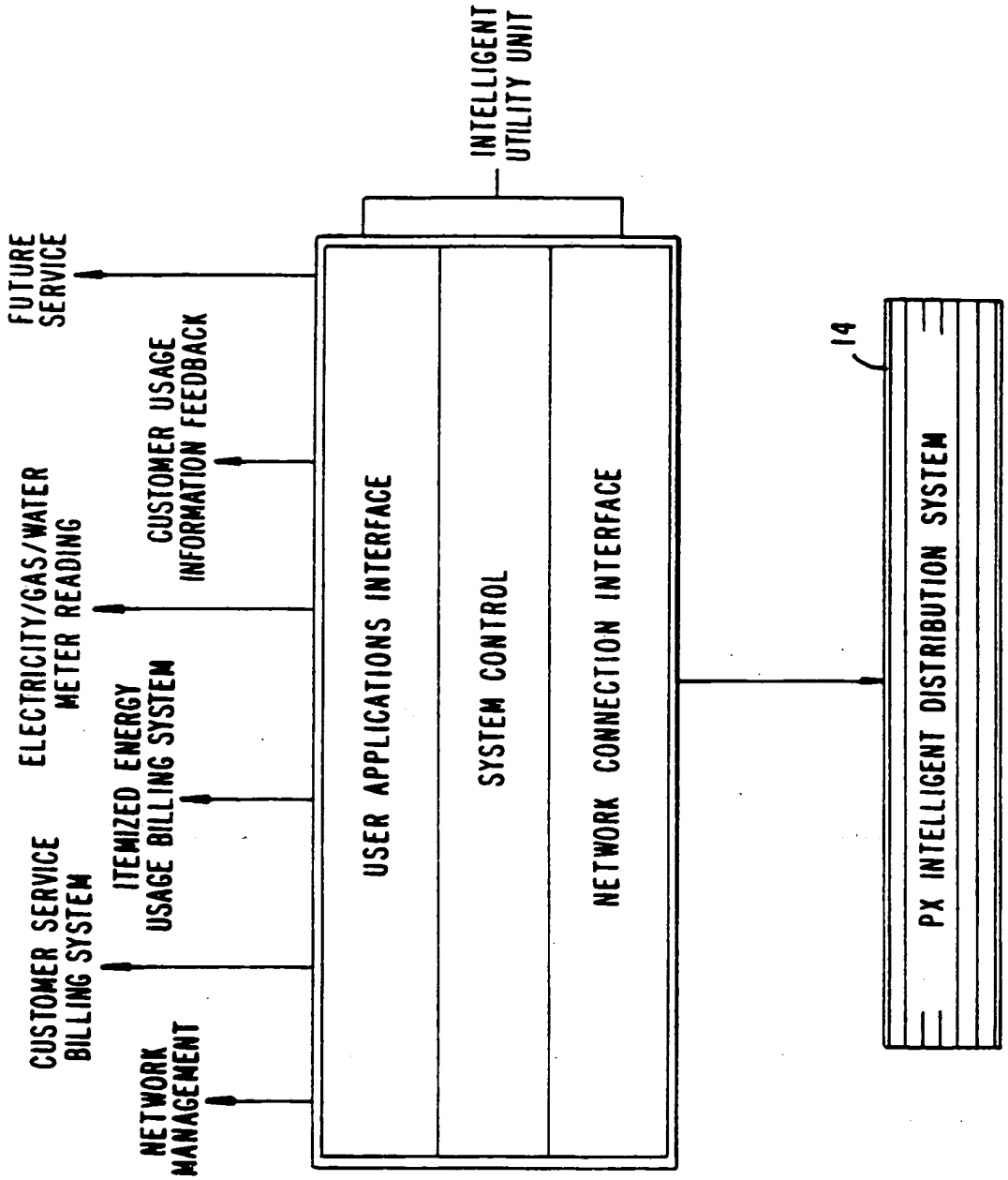
INTELLIGENT UTILITY UNIT
FUTURE SERVICE
ELECTRICITY/GAS/WATER METER READING
CUSTOMER USAGE INFORMATION FEEDBACK
ITEMIZED ENERGY USAGE BILLING SYSTEM
CUSTOMER SERVICE BILLING SYSTEM
NETWORK MANAGEMENT
USER APPLICATIONS INTERFACE
SYSTEM CONTROL
NETWORK CONNECTION INTERFACE
14
PX INTELLIGENT DISTRIBUTION SYSTEM

FIG. 3.

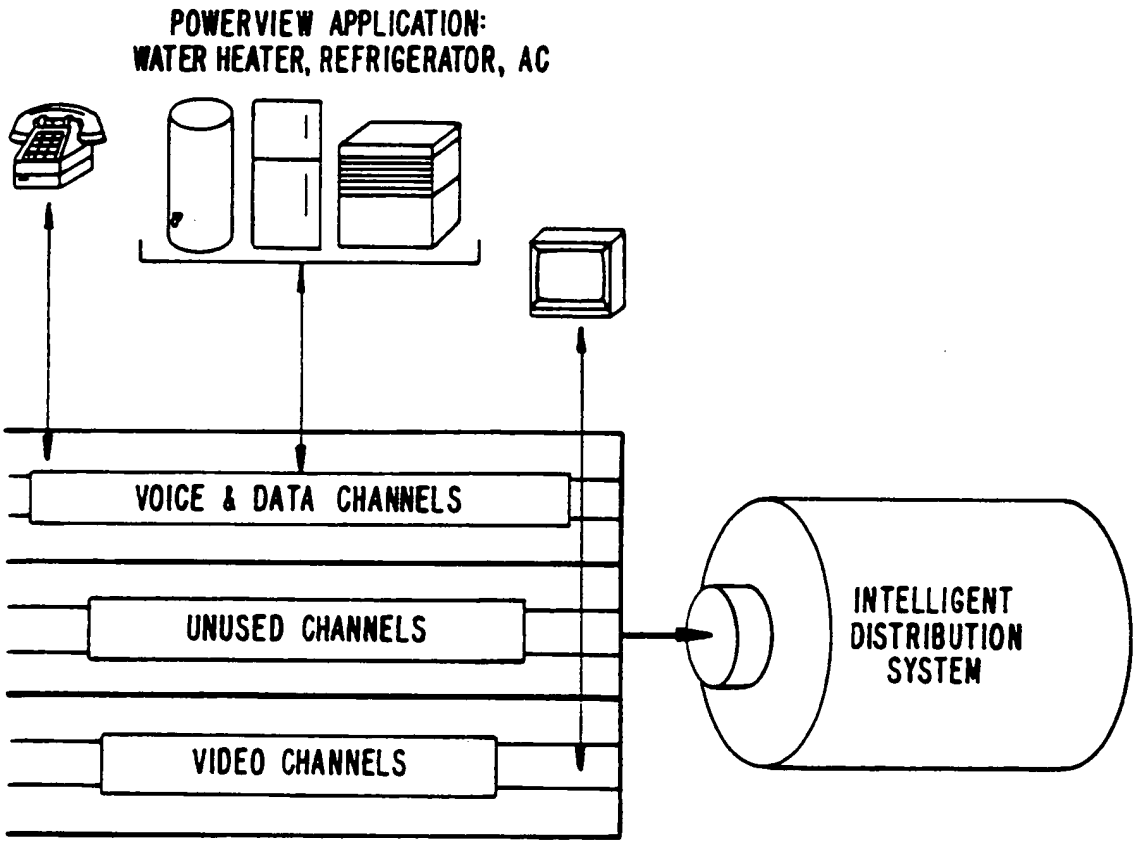
POWERVIEW APPLICATION:
WATER HEATER, REFRIGERATOR, AC
VOICE & DATA CHANNELS
UNUSED CHANNELS
VIDEO CHANNELS
INTELLIGENT
DISTRIBUTION
SYSTEM

FIG. 4.

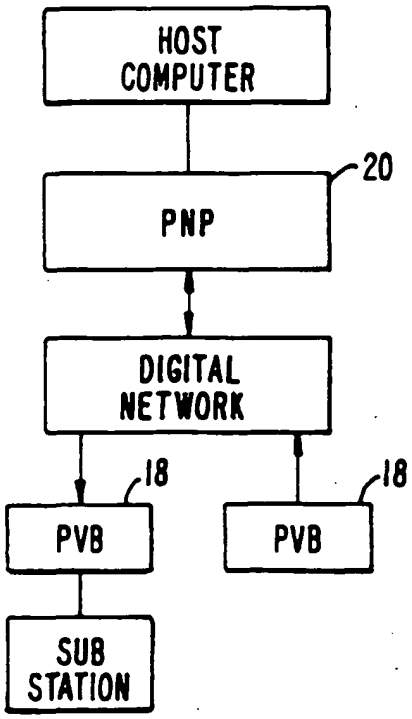
HOST COMPUTER
20
PNP
DIGITAL NETWORK
18
18
PVB
PVB
SUB STATION

FIG. 5.

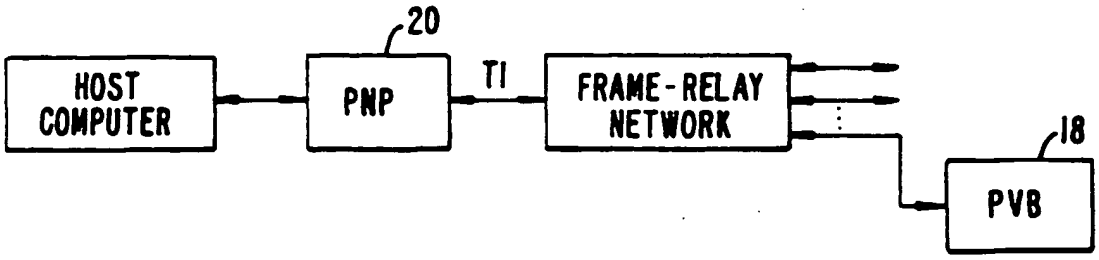
20
HOST COMPUTER
PNP
T1
FRAME-RELAY NETWORK
18
PVB

FIG. 6.

European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 96 30 1661

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.6)
Y A	EP-A-0 019 287 (TOCOM,INC.) * page 4, line 16 - page 10, line 20; figures 1-5 *	1,9 2-4,10, 11	H02J13/00
Y	EP-A-0 407 902 (ALCATEL) * column 2, line 31 - column 4, line 27; figure 1 *	1,9	
A	US-A-5 040 175 (TUCH ET AL) * column 2, line 56 - column 7, line 49; figures 1-7 *	1,2,9	
A	EP-A-0 503 464 (ALCATEL) * column 2, line 54 - column 8, line 21; figures 1,2 *	1,6,9	
A	EP-A-0 265 342 (SANGAMO WESTON) * column 4, line 50 - column 12, line 57; figures 1-4 *	1,9	
A	WO-A-95 12911 (UHER AG) * page 2, line 26 - page 3, line 35; figure 1 *	1,9	TECHNICAL FIELDS SEARCHED (Int.Cl.6) H02J
A	FR-A-2 677 469 (EURO CP) * page 3, line 12 - page 4, line 26; figures 1-3 *	1,9	
A	ELEKTROTECHNIK UND INFORMATIONSTECHNIK, vol. 107, no. 7/8, 1990 - 1990, WIEN, pages 371-378, XP000150972 HACKL: "entwicklungstendenzen der modernen betriebsführungstechnik" * the whole document *		

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	18 June 1996	Calarasanu, P

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
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E : earlier patent document, but published on, or after the filing date
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L : document cited for other reasons

& : member of the same patent family, corresponding document

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